Lower Elwha Klallam Tribe

Tsunami

Train the Trainer Guidebook 2012

This Washington State Emergency Management Project was developed in partnership with SesimicReady Consulting, Inc., and the National Tsunami Hazard Program

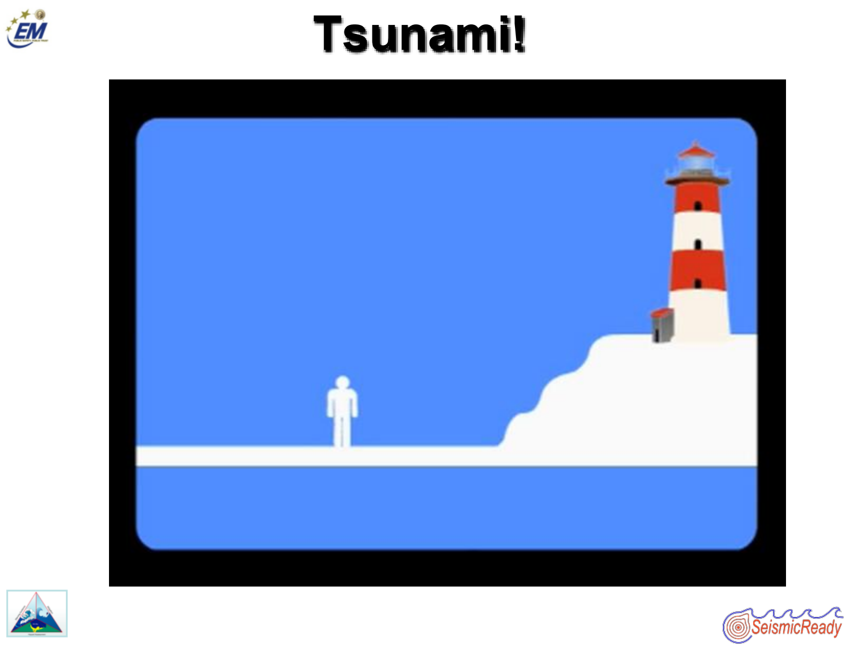
Train The Trainer (T-3) Course

Facing the Tsunami Hazard

Slide 1. Course Introduction

The Tribe is vulnerable to both distant tsunamis (such as the 1964 Alaska Earthquake and Tsunami) and local tsunamis (1700 Cascadia Subduction Zone Earthquake and Tsunami). This course provides participants with an understanding of the tsunami hazard, current hazard assessment tools and products, tsunami warning and dissemination systems, effective public response and potential challenges in educating the public.

Public education is a critical component of the preparedness process and with the participants help, the Tribe can provide people with the knowledge and tools they need to make the right choices when a tsunami strikes their community.



Slide 2. Tsunami!

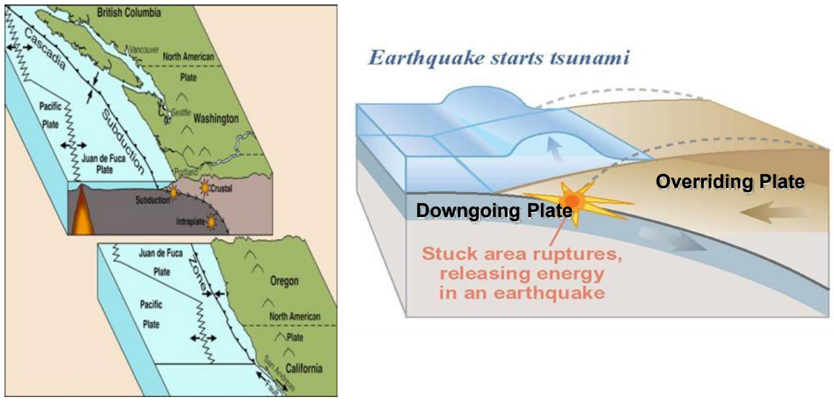
In 2011, the International Tsunami Information Center, NOAA/PMEL and SeismicReady Consulting created a 6-min video on the basics of tsunamis. Topics include what is a tsunami, how to recognize a tsunami and what to do when you know a tsunami is coming. In the video, the Mayor of Poloa, American Samoa recounts his actions when the tsunami hit his village on September 29, 2009. That day, waves were as high as 50 feet elevation.

What is a tsunami?

“Tsunami” is a Japanese word. **Tsu** means “harbor” and **nami** means “wave.”

A tsunami is a series of giant waves produced by underwater movement due to a variety of natural events, such as earthquakes, volcanic eruptions, landslides and meteorites. In Washington, earthquake and landslides are the most likely sources of a tsunami. In deep water of the open ocean, tsunamis cause no damage and are hardly noticed, even though they can travel as fast as an airplane. As the tsunami wave approaches shore from the open ocean the wave slows down and can grow as high as 100 feet. A person cannot out run a tsunami. Tsunamis can flow inland for tens of minutes while wind waves flow inland for tens of seconds. Tsunamis can create strong currents. Therefore, even a small tsunami can be dangerous. Remember a tsunami is not one wave, but a series of waves. The time between successive wave crests is usually tens of minutes apart and continues arriving for many hours. The first wave is almost never the largest. For instance, in a modeled Cascadia Subduction Zone event the first wave could reach tribal land within 1½ hours or less.

Local Tsunami from Cascadia Earthquake

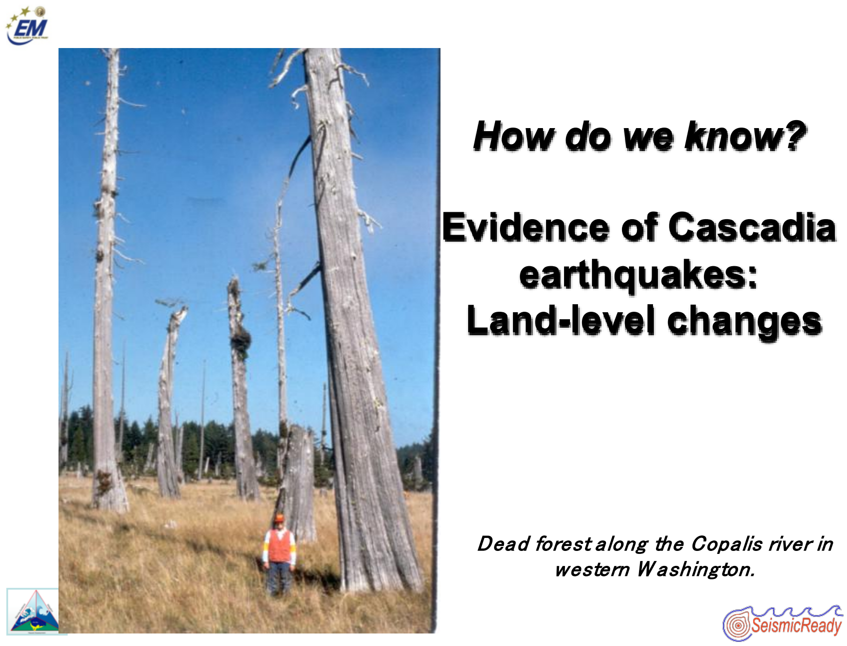


Tsunami arrives within 30 minutes or less

Slide 3. Cascadia Subduction Zone

Cascadia subduction zone is the long fault boundary between the North American and Juan de Fuca plates. The zone stretches from northern Vancouver Island to Northern California and has produced great-magnitude earthquakes that have generated tsunamis at least six times in the past 3,500 years. The most recent occurred on the evening of January 26, 1700. During this earthquake and that of its predecessors, much of the land on Washington's outer coast subsided, or fell, by about five feet. Such lowering of the land caused flooding of coastal low-lying areas and killing western red cedar forests and other vegetation.

Subduction is a geological process in which one edge of a crustal plate is forced downward into the mantle below another plate. For example, the Juan de Fuca plate descends beneath the North America, this process is known as subduction. Accumulated energy raises the seafloor (and the water above it) and a tsunami can be created.



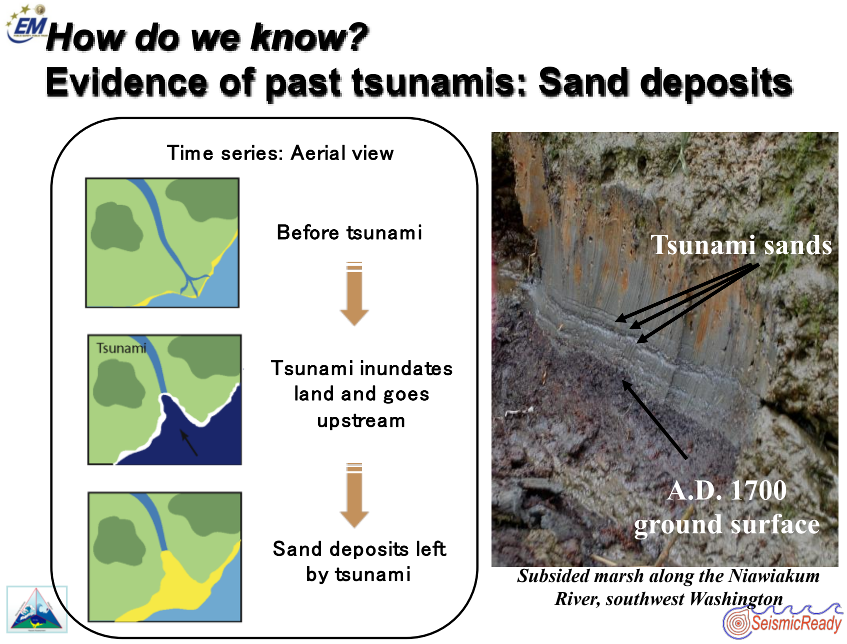
Slide 4. Evidence of Cascadia Subduction Zone Earthquake

How do we know when the last Cascadia Subduction Zone earthquake occurred and that it produced a tsunami?

The answer is blowing in the wind along the Washington coast. This is a picture of a dead forest along the Copalis River, about a mile or so from the Highway 109 Bridge. The dead trees in this picture are western red cedars, and as you probably know, are very resistant to rot once they die.

How did these trees die?

They were killed by salt water. During the 1700 earthquake, imagine these trees covered with thick, green branches. Then, during the earthquake, the marsh along the Copalis River suddenly drops, and salt water rushes in. The trees slowly die from the salt water, and as the river still flows, it slowly begins to rebuild the marsh. But the trees finally die. Some 300 years later, a paleoseismologist matches the tree rings of a dead tree and compares it to some of the long-lived cedar trees along the coast. That match tells the paleoseismologist that the tree died during the winter of 1699-1700. This is the evidence that a significant Cascadia Subduction Zone earthquake occurred about 1700.

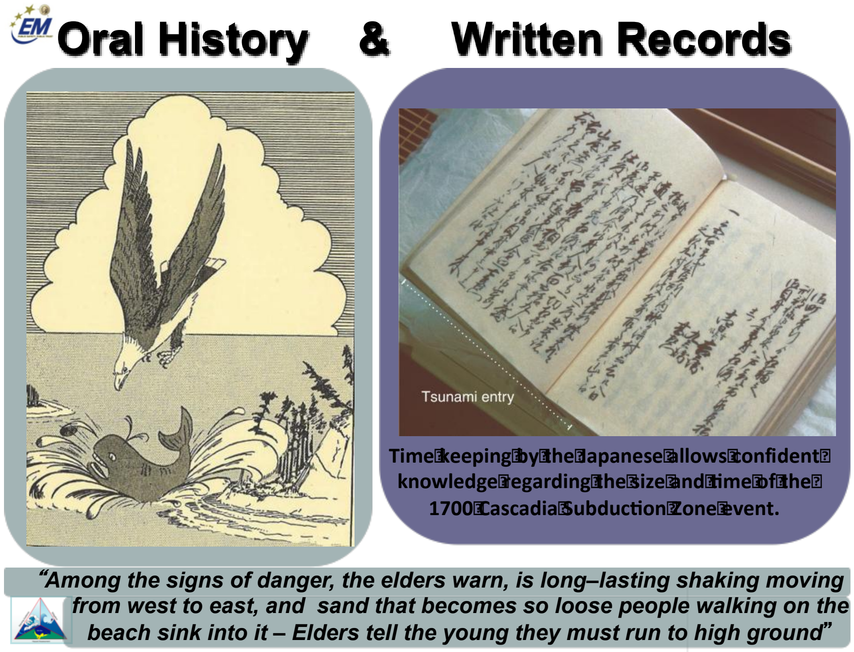


Slide 5. Evidence of Cascadia Subduction Zone tsunami

Tsunamis pick up very distinctive sands (sometimes the minerals are different or there are marine microfossils like foraminifera or diatoms - like plankton) as they form, and they deposit those on the beaches as they wash over the landscape. Similar to the killing and burial of the Copalis River trees, tideflat mud covers and buried tsunami sands (At Niawiakum the bottom is forest peat, then tsunami sand, then marine mud).

Sedimentary tsunami deposits allow geologists to expand the record of tsunamis, improving hazard assessment. Frequency and magnitude, two primary factors in tsunami hazard assessment, can be assessed through tsunami deposits. Where more than one tsunami deposit is preserved, the possibility is presented to determine tsunami recurrence.

The tsunami deposit can tell the minimum distance inland and run up as well as the minimum current needed to move the sediment. So it helps us understand the range of current strength and inundation.



Slide 6. Evidence of Cascadia Subduction Zone Earthquake and Tsunami

Oral History

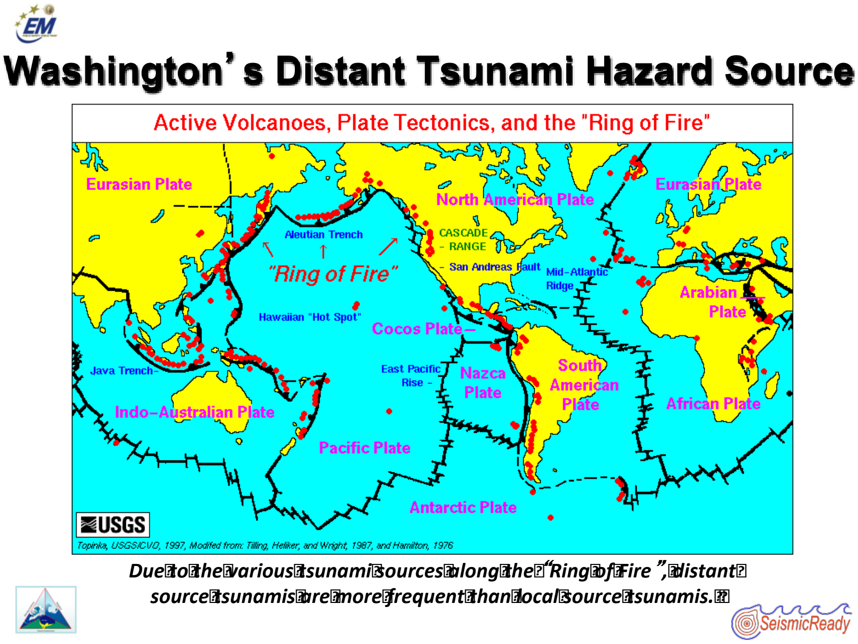
Oral history has been used by many cultures throughout the world to educate and pass information from generation to generation. For example, oral traditions of Native American tribes of the Washington Coast describe what is interpreted as a huge earthquake and tsunami destroying coastal villages. This tradition has been very helpful to complement scientific data and develop hazard assessment tools.

Written Records

It is the accurate written records from samurai, merchants, and villagers of the tsunami and the accurate time keeping by the Japanese that allows confident knowledge of the size and time of the 1700 Cascadia Subduction Zone event.

Reference

Atwater, Brian F., Musumi-Rokkaku Satoko, et al. (2005). The Orphan Tsunami of 1700. (No. 1707). Seattle, WA: U.S. Geological Survey.
http://pubs.usgs.gov/pp/pp1707/

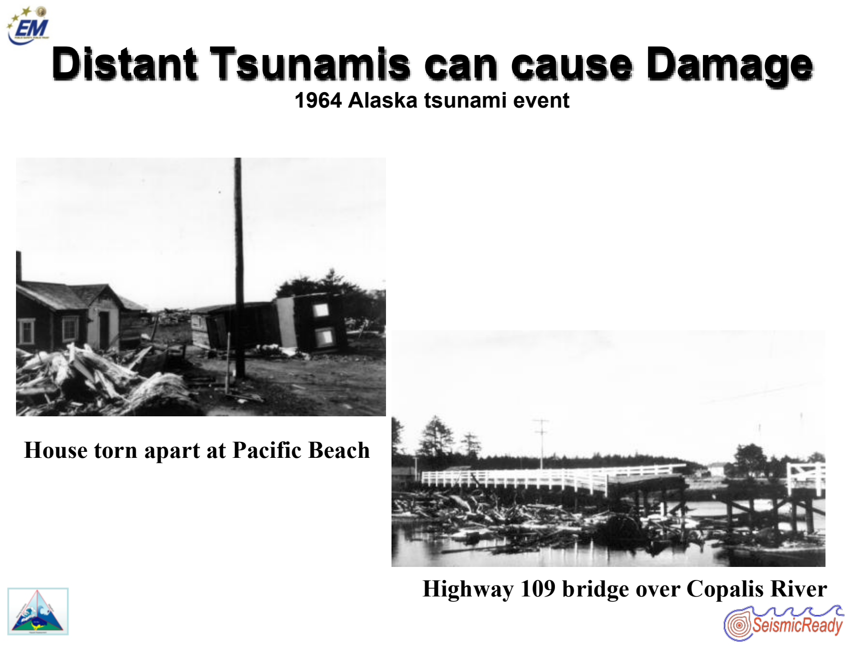


Slide 7. Washington's Distant Tsunami Sources

Scientists cannot accurately predict when or where an earthquake will occur. The majority of the earthquakes and volcanic eruptions occur along plate boundaries such as the boundary between the Pacific Plate and the North American plate. One of the most active plate boundaries where earthquakes and eruptions are frequent, for example, is around the massive Pacific Plate commonly referred to as the Pacific "Ring of Fire".

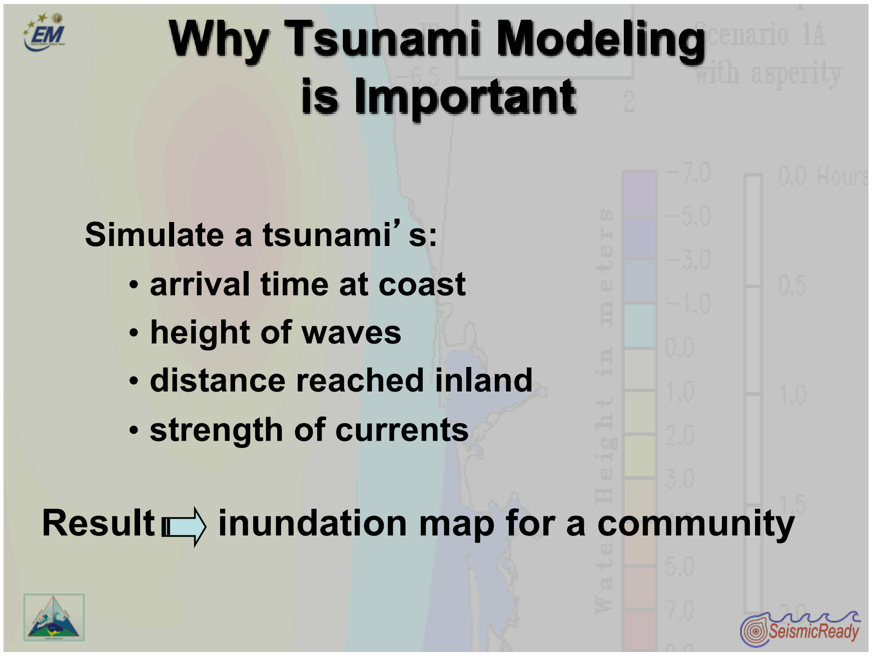
Earthquakes are relatively brief, but their effects range far and wide. Aftershocks may spread over days or even months. The impact of the quake may be felt hundred of miles from its epicenter. A severe quake may trigger a chain of events, such as tsunamis, landslides, fires, floods, and pollution that extend the damage and add to the panic and the casualties.

Due to the various tsunami sources on the "Ring of Fire", distant source tsunamis are more frequent than local source tsunamis. Historical records (up to 1854) and geologic investigations indicate that tsunamis have struck Washington's shores numerous times. While only one tsunami has caused major damage (1964 Alaska Earthquake), strong currents accompanying a tsunami threaten the maritime industry as well as individuals in and around the water. For example, a 1960 earthquake along the coast of Chile generated a tsunami causing non-destructive inundation at Grays Harbor, Tokeland, Ilwaco, Neah Bay, and Friday Harbor. A tsunami originating in Alaska can strike the Washington coast in 2 hours. The 1964 event, from a Mw 9.2 earthquake, was recorded with a travel time to Neah Bay of 3 hours and 42 minutes. Wave heights ranged between 5 – 15 feet in Washington.



Slide 8. Damage caused by the 1964 Alaska Tsunami

While distant tsunamis have caused significant damage, deaths and injuries in Oregon and California, only one significant tsunami struck Washington's Pacific coast in recent history. The 1964 Alaska earthquake generated a tsunami that resulted in debris deposits throughout the region, minor damage in Ilwaco, damage to two bridges on State Highway 109, a house and smaller buildings being lifted off their foundations in Pacific Beach, and piling damaged at the Moore cannery near Ilwaco. The tsunami was also recorded inland in the Strait of Juan de Fuca (Friday Harbor), Puget Sound (Seattle), and the Columbia River (Vancouver) but caused no damage.

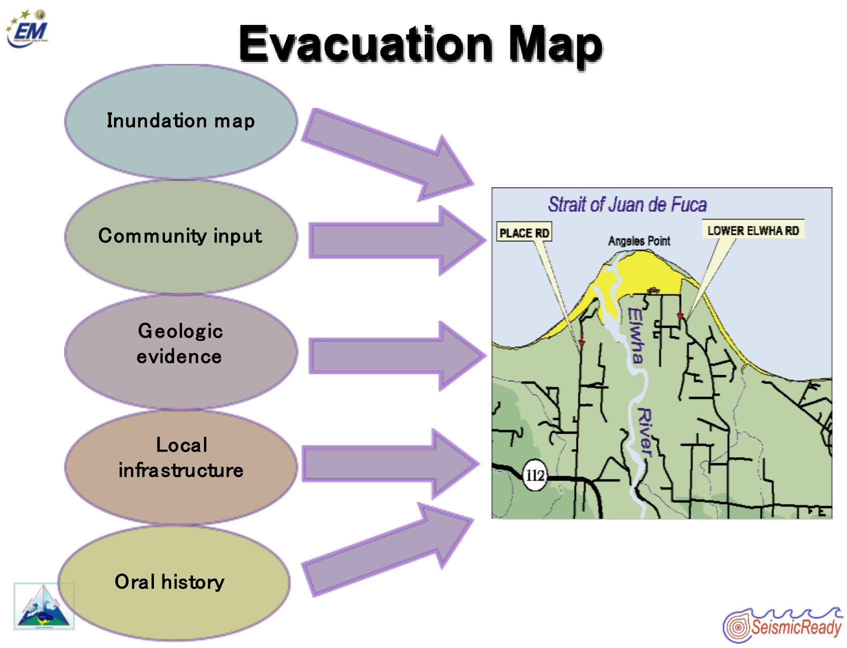


Slide 9. Why Tsunami Modeling is Important

Often more than one tsunami scenario is utilized to develop an inundation map. Tsunami source location, magnitude and other attributes result in distinct affects to a particular location. Thus, it is imperative to utilize more than one credible scenario to create a tsunami inundation map. The tsunami source above is based on prior work by Walsh et al., (2000) which simulate a great Mw 9.1 Cascadia Subduction Zone earthquake with an asperity off the coast of northern Washington. Details of this scenario and the model results are provided in Venturato et al., 2007.

Reference

Venturato, A.J., D. Arcas, and U. Kânoğlu (2007): Modeling tsunami inundation from a Cascadia subduction zone earthquake for Long Beach and Ocean Shores, Washington. NOAA Tech. Memo. OAR PMEL-137, NOAA/Pacific Marine Environmental Laboratory, Seattle, WA, 26 pp. http://nctr.pmel.noaa.gov/animations/inun_animation_lb_logo.mov



Slide 10. Evacuation Map

Modeled inundation, contributes to developing the inundation area. Once an inundation line is drawn, the line is not permanent. New techniques for tsunami modeling are always improving the capacity to create more effective inundation maps. Also, difficult to detect land changes (e.g. topography and bathymetry) can effect tsunami inundation mapping. Consequently, inundation maps should be used for guidance in planning not as a definitive and permanent map.

Evacuation maps, routes and assembly areas can be identified once inundation modeling and mapping is developed.

Special needs populations should determine evacuation assembly areas or vertical evacuation refuge sites. Special needs populations must be able to reach safe sites within the expected wave arrival time for safe evacuation.

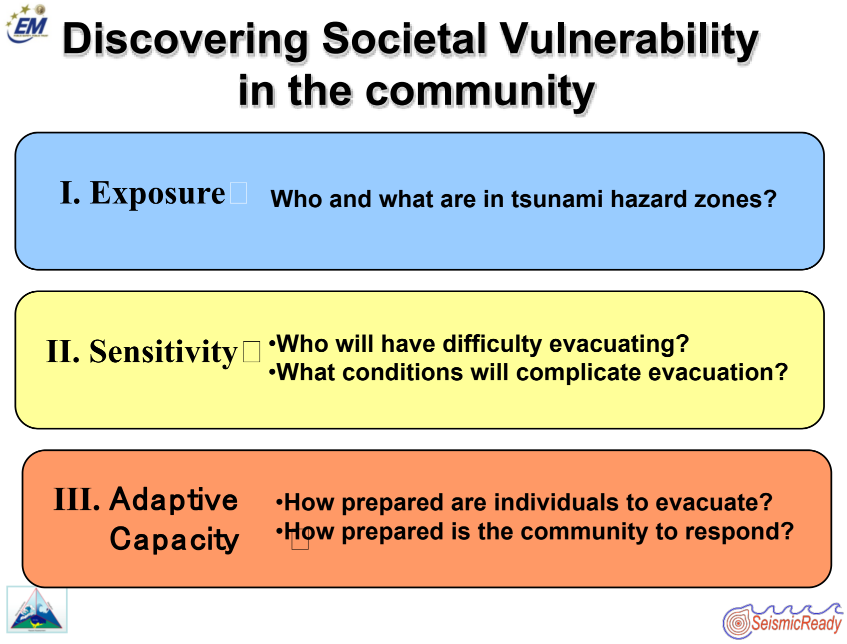
Tsunami Evacuation Map Brochures should be developed for visiting, or tourist populations. Tsunami evacuation routes should be adequately marked with signage. Official tsunami signage creates pre-event awareness and improves life safety.

Slide 11. How to Reduce Risk

Hilo, HI has been destroyed by several major tsunamis, which includes the 1960 Chile Tsunami (left photo). Today, the city has been moved back and the area where the city once was is now a park – Land use planning is one way to help reduce the risk of tsunamis and the economic impact that a tsunami can have on a community. **Photo Sources: Hilo, 1960: Honolulu Advertiser; Hilo, 2010: Google Maps, DigitalGlobe**

Evidence of past tsunami events identify that tsunamis are a significant threat to your communities from both a local (Example: 1700 Cascadia Subduction Zone) and distant (Example: 1964 Alaska Earthquake/Tsunami) events.

Over the years, these coastal communities have grown in both population and built environment increasing their vulnerability. Results of a perception study of residents and tourists on the outer Washington coast indicate that hazard awareness was high among survey participants, but awareness levels did not translate into preparedness actions (Johnston and others, 2005). In an effort to correct this deficiency, you will be introduced to the use of evidence-based approaches in social and behavioral sciences that are tailored to a community's specific risk and vulnerability.



Slide 12. Discovering Societal Vulnerability in the Community

By understanding a community's hazard exposure, physical vulnerability, and social vulnerability, evacuation planning, public education, and other preparedness and response programs can be developed.

Exposure – Population, assets and resources that are in the tsunami hazard zone (Number and types of individuals including tourists and employees that transit into the tsunami hazard zone, businesses, cultural and natural resources, roads, bridges, utilities). **Example, 25% of the tribal community lives in the tsunami hazard zone and approximately 7% are over 65 years old.**

Sensitivity - What conditions will complicate evacuation? For example in your tsunami hazard zone there are the elderly and disabled that may have difficulty or Incapable of evacuating on their own and will require outside assistance to evacuate.

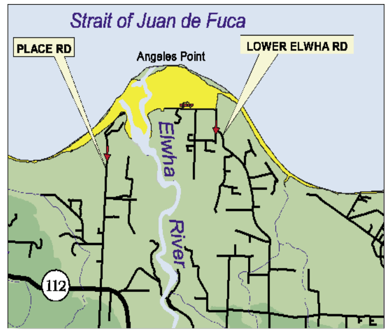
Adaptive Capacity - Ability to manage risk, adapt during crisis and recover from tsunami. How prepared is he community to respond? Is regular pubic education given and tsunami drills done? How will individuals receive warning? Are people educated on the type of warning systems in the community and know the natural queues for a local tsunami event?

Reference

Variations in Community Exposure and Sensitivity to Tsunami Hazards in Washington
Wood, Nathan, and Soulard, Christopher, 2008, "Variations in community exposure and sensitivity to tsunami hazards on the open-ocean and Strait of Juan de Fuca coasts of Washington," U.S. Geological Survey Scientific Investigation Report 2008-5004, 34p. http://pubs.usgs.gov/sir/2008/5004/

Tsunami Evacuation Map

"Local tsunami evacuation maps developed from inundation modeling, mapping, and community input"



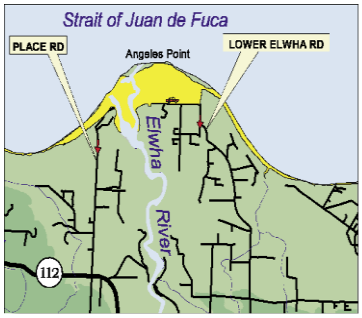
Slide 13. Tsunami Evacuation Map

When planning and developing tsunami evacuation routes, a community uses exposure and sensitivity data to identify the location of special population groups lacking the ability to anticipate, cope with, resist and recover from the impacts of a tsunami. For example, people aged 66 and above accounted for 90% of the indirect death toll from the Great East Japan Earthquake and Tsunami (Japanese Times, May 12, 2012). Those that are in need of help to evacuate (without cars, the elderly, handicap etc.) should talk to neighbors and community support groups (example: Map your neighborhood program) to pre-arrange evacuation to high ground.

Overall there was a 96% survival rate of those living in the inundated area of the municipalities surveyed in Japan after the Mar 11 Japanese earthquake and tsunami. The high survival rate can be attributed to mostly effective education and evacuation procedures. Schools education, hazard maps and exercises appeared to be the common forms of education. Majority of coastal communities were engaged in planning of evacuation maps, routes and many communities conducted regular community-level exercises. However, inundation and evacuation maps lacked consistency and both maps and safe locations were generally designed for a tsunami height that under-represented the worst-case scenario (GNS Science Report 2012/17).

Remember that special populations in the community will require additional time to arrive to an evacuation assembly area. It is recommended that the public familiarize themselves with the evacuation routes closest to them and walk the routes to see how long it takes to get to an assembly area. That time is then compared to the expected wave arrival time identified by the tsunami model that was used to develop the inundation map.

Evacuation Problems?



Issues:

•No high ground exists
•No time to go inland to high ground
•Special needs populations

Solutions:

- Vertical evacuation
- Vertical evacuation refuge

www.facebook.com/ProjectSafeHaven

Slide 14. Evacuation Problems?

In some locations, high ground may not exist, or tsunamis triggered by local events may not allow sufficient warning time to evacuate to high ground. The only solution is to evacuate in place, meaning vertical evacuation into the upper levels of structures. Things to consider for vertical evacuation are:

- Reinforced concrete buildings do better than wood frame building
- Look for a structure that is back away from the beach and on higher ground – it will help reduce tsunami depth and velocity
- Debris such as cars, trees, logs and damaged building can cause damage to a building by a tsunami wave
- Avoid hazardous material sites, if possible

If you can't evacuate inland and there are no high structures nearby, then you should find the tallest, sturdy structure and climb up and cling to it until the wave passes. In some cases, this might only be a strong tree or utility pole. If you're swept up by a tsunami, look for something to help you stay afloat, and to protect you from dangerous floating debris like houses, cars, and trees.

There is guidance out on vertical evacuation structures: FEMA P646, Guidelines for Design of Structures for Vertical Evacuation from Tsunamis and FEMA P646A, Vertical Evacuation from Tsunamis: A Guide for Community Officials. These structures designed for vertical evacuation from tsunamis are called vertical evacuation refuges. They are designed for short-term protection (12-24 hours), of sufficient height to elevate evacuees above the level of tsunami inundation, and designed to withstand an earthquake and resist tsunami loads. The state tsunami program is working with local officials on the development and funding of these sites in at-risk communities that have no high ground. For example, Grays Harbor County has held community workshops to get community input to develop the type and location of vertical evacuation refuges for identified communities (http://www.facebook.com/ProjectSafeHaven).

Community Preparedness

TsunamiReady Program:
Lay the foundation for communities to reduce the impact of a tsunamis

Slide 15. Community Preparedness

Minimum guidelines have been developed for communities and counties to follow for adequate tsunami readiness that encourage consistency in educational materials, response, and planning among coastal communities. The program recognizes communities that have taken the steps necessary to prepare their emergency response infrastructure and population for a tsunami emergency and who have increased public awareness and understanding of the tsunami hazard. Funding through the TsunamiReady Program and the National Tsunami Hazard Mitigation Program supports communities in meeting the guidelines to be recognized as "TsunamiReady."

For more information on the program contact:

- Your local or state emergency management agency
- The NWS TsunamiReady website: www.stormready.noaa.gov
- National Tsunami Hazard Mitigation Program website: www.nthmp.tsunami.gov/

Remember

A community that is designated as a "Tsunami Ready Community" does not mean that they are 100% prepared to respond to a tsunami.

Neighborhood Preparedness

•First Responders may be overwhelmed and unable to immediately assist individuals

•Neighbors will be the first ones to offer assistance.

•Map Your Neighborhood program provides excellent guidance

In a disaster, your most immediate source of help are the neighbors living around you

SeismicReady

Slide 16. Neighborhood Preparedness

- First Responder capabilities such as fire, police, medics, and utility personnel will be overwhelmed and unable to immediately assist individuals
- Neighbors will likely be the first ones to offer you assistance. Neighbors that are prepared are more effective in their response to a disaster
- Map Your Neighborhood (MYN) provides excellent guidance on developing a neighborhood program

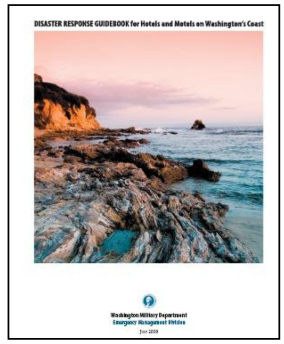
Action Messages:

- **Take care of yourself and help others if you can**
- **Help create a MYN in your neighborhood**

Hospitality Industry

First line of contact with tourists

- Educate and train business on tsunami contingency planning
- Staff trained on what to do for a tsunami



Resource for Hotels & Motels on Washington Coast is available!

Slide 17. Hospitality Industry

Disaster Response Guidebook for Hotels and Motels

- Guidebook provides checklist for tsunami warning and evacuation
- Provide individual staff training
- Provide business with a tone alert radio and instructions
- Provide outreach materials for customers and for rooms

For more information call the Washington State Tsunami Program, Noemi LaChapelle at 253-512-7082 or Noemi.LaChapelle@mil.wa.gov

Preparedness is a shared RESPONSIBLITY

1,500 people died in this train while two reinforced concrete buildings a few steps away were virtually undamaged

"To survive a tsunami, individuals in tsunami prone communities must have the knowledge to take correct actions quickly"

SeismicReady

Slide 18. Preparedness is a shared Responsibility

This photo is a good example of people not understanding the hazard and appropriate actions they can take to survive a tsunami.

Make sure your briefings provide a consistent message that is being used throughout your communities. An inconsistent message will cause confusion and lead to a wrong action. Always end your public education messages with an action.

Example based on photo above:

When you are in a tsunami hazard zone you must know the natural cues of a tsunami, i.e., **ground shaking, sea level changes, a loud roar** = **ACTION –> Head to high ground immediately. If not high ground vertically evacuate.**

Personal Preparedness Actions

Citizens must:

- Know the Tsunami Hazard for their community
- Have a copy of the community's Tsunami Evacuation map/brochure
- Know the evacuation routes and assembly area
- Have a family emergency plan
- Know where each family member would go for various scenarios
- Practice the plan
- Reeducate on a regular basis
- Have a pre-packed emergency kit

"Be prepared to be self-sufficient for multiple days"

SeismicReady

19. Personal Preparedness Actions

Based on our discussion of "Why we discuss vulnerability", public education must not focus on the uncontrollable tsunami hazards. Instead, focus should be on individual actions that can reduce a tsunami's impact.

The above are positive action messages citizens can take to survive a tsunami. As you go through each one, ask the audience to comment and solicit their input – this is one way to help them buy-in to self preparedness and understanding they can control the outcome of a tsunami strike.

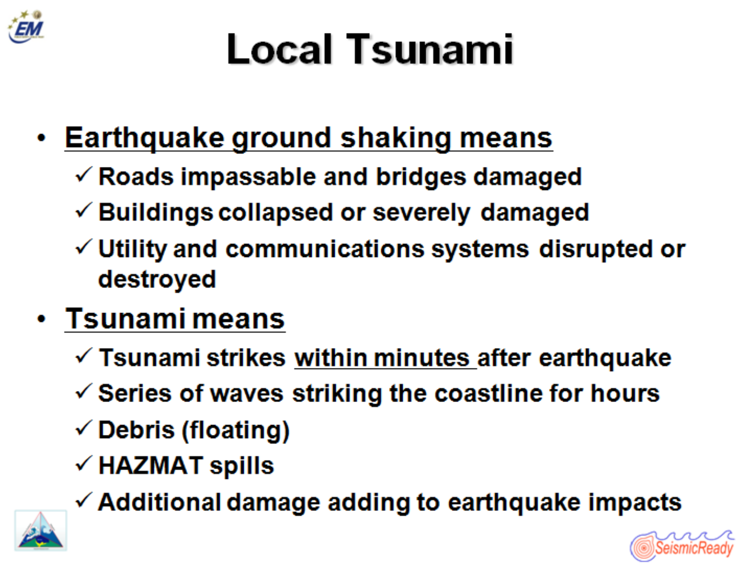
How to Respond to a Tsunami

Fleeing the tsunami, Hilo, 1946

20. How to respond to a Tsunami

Photo shows people fleeing in Hilo Hawaii. An earthquake occurred on Apr 1, 1946 in the Aleutian Islands of Alaska. Near the source of the earthquake, at Unimak Island, huge tsunami waves reached more than 100 feet above sea level and destroyed completely the newly built, U.S. Coast Guard's Scotch Cap lighthouse. All 5 men of its crew were killed. The lighthouse was a steel-reinforced concrete structure and its base was at about 90 feet above sea level. To Unimak Island and other area of Alaska this was a local event giving no warning other than **natural cues**. The tsunami arrived 4.9 hours in Hilo after the tsunami was generated. It caused $26 million (1946 dollars) and 96 people lost their lives. For Hilo, this was a distant event. There was no Tsunami Warning Center in 1946 but if people would have been educated on the tsunami hazard and understood **tsunami natural cues**, loss of life in Hilo would have been minimal to none. **Source:** Bishop Museum Archives.

Community citizens must understand that they may deal with either a local tsunami (example: 1700 Cascadia Subduction Zone Earthquake/Tsunami) or a distant tsunami (example: 1964 Alaska Earthquake/Tsunami). The response for both types of tsunamis is different – their lives and those of their love ones depend on the correct response actions.



Slide 21. Local Tsunami

A local Cascadia event will require the public (as well as responders) to deal with the earthquake and it's consequences. A major earthquake can destroy the built environment that will hamper the evacuation of the public to higher ground – the public must consider extra time needed for evacuation and have a plan that helps support special needs population. Local response will mean that the public will have to be prepared to self-evacuate on the natural cues and not depend on response personnel to be available to support evacuation out of the tsunami hazard zone.

In a local event, a tsunami wave will arrive within 1½ hours or less after the earthquake (Wave arrival time based on modeling and inundation mapping data and identified in your tsunami brochure). Some areas could also be flooded by land changes that the public will further have to deal with. The tsunami strike can last for hours that will be a series of waves. The first wave may not be the most damaging and people may have to vertically evacuate to escape the tsunami and head to an evacuation assembly area as best they can. Be aware that secondary hazards such as fire and other HAZMAT that can be associated with the tsunami and will need to be dealt with both during evacuation and during response before an "all clear" can be given by local authorities to return back to the tsunami hazard zone.

Local Tsunami Response

- **How will the community be notified?**
  - ✓ **Natural cues are the warning notification!**
    - ➢ **Little or no official warning disseminated in a timely manner**

Slide 22. Local Tsunami Response

For local events, natural cues will be your warning notification to **self-evacuate**. **Know these natural cues**:

- Strong ground shaking lasting up to several minutes
- Unusual ocean activity, especially if the ocean recedes seaward exposing the sea bottom, rocks and fish, or the ocean rapidly rises in elevation looking like a wall of water
- Loud roaring sounds from the ocean, like an approaching airplane or train

Understanding these signs saved thousands of lives during the December 26,2004 Indian Ocean Tsunami, the September 29, 2009 South Pacific Tsunami in American Samoa and Samoa, and the February 27, 2010 Chile Tsunami and March 11, 2011 Japanese Tsunami. Survivors tell of the loud roar sounding like an airplane or train as the tsunami approached. On February 27, 2010 in Chile, the strong earthquake shaking was the first natural warning that woke many up at 3:30 am early that morning and On March 11th in Japan the strong grounding shaking caused mass evacuations prior to the official warning.

NOTE: In Japan, the natural warning of long ground shaking (reported as more than two minutes, and often more than three) on March 11th was widely agreed as enough by itself to have triggered evacuation. Sea walls reduced effective observation of the natural warning of unusual ocean behavior in many communities, and fostered a false sense of security in some locations (GNS Science Report 2012/17).

Local Tsunami Response

- **How will the community be notified?**
  - ✓ **Natural cues are the warning notification!**
    - ➢ **Little or no official warning disseminated in a timely manner**

Slide 22. Local Tsunami Response

(Continued)

Tsunami warning centers will get the warning message out quickly but may not be received in enough time to safely evacuate to high ground. Because the response actions will be immediate, the public will need to be prepared to response to the event on their own and take immediate action to move to high ground.

Action Messages

- Know tsunami natural cues
- Drop, Cover and Hold On for strong ground shaking
- Head inland and to high ground immediately

Local Tsunami Response

What about first responders?

- **Emergency Operation Center probably not activated to enable an evacuation during non-duty hours**
- **Little to no response personnel available to support evacuation**

Slide 23. Local Tsunami Response

A local earthquake event has potential to cause damage to the built environment leaving the tribal officials and responders to deal with destruction of the earthquake and a potential destructive tsunami within tens of minutes after the earthquake. Depending on the time of the event, there could be minimal responders available to deal with the response. The earthquake will cause major damage which will require responders to respond to the earthquake or hamper them supporting response efforts before they can support the tsunami evacuation of coastal residents. Therefore, the public will need to be prepared to respond on their own.

Note for response agencies: For a local event, response personnel need to evacuate the hazard zone immediately and not become a victim – DO NOT ENTER THE HAZARD ZONE UNTIL TOLD TO DO SO. First priority should be self and family then support response.

Remember assembly areas are out of the inundation zone and where response personnel will focus their attention – however, food, water, etc., may not be available for some time. See the community tsunami brochure for items that should be a disaster supply kit.

Action Messages

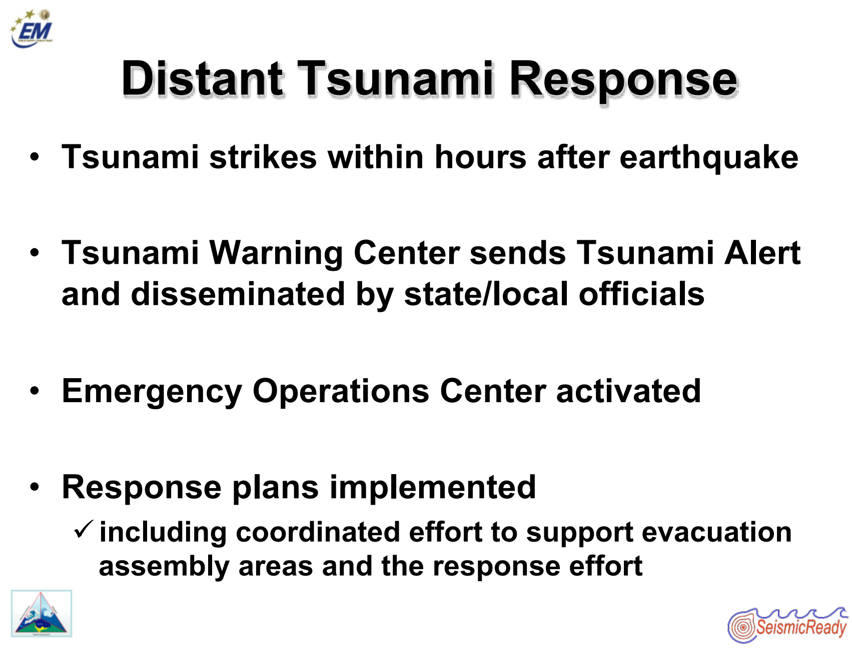
- Develop a family plan
- Be familiar with emergency management and tsunami plans
- Know where the nearest assembly area is and how to get there
- Prepare a disaster supply kit

Slide 24. Local Event – WALK!

In Japan, traffic congestion was a significant issue in several locations during the evacuation on March 11th 2011, although other locations reported minimal congestion and attributed this to previous guidance to evacuate the hazard zone by foot rather than motor vehicles. Events on March 11th provide support for the approach currently taken in Washington, which is to encourage tsunami evacuation on foot wherever possible (GNS Science Report 2012/17).

Other issues to consider for not driving:

- Failure of traffic signals during a power outage,
- Poor road conditions immediately following an earthquake,
- Vehicles clogging roadways,
- Vehicles may become battering rams, and
- Evacuation locations may quickly fill up leaving no room for others evacuating



Slide 25. Distant Tsunami Response

Distant tsunamis give the federal, state, tribal and local governments time to assess the tsunami risk and make decisions on evacuations. Tsunami Warning Center will provide information on tsunami generation and recommended actions. They will provide updated information every 30 minutes. Emergency Operation Centers will be activated and staffed with tribal/government officials who will coordinate the evacuation and response effort at all levels. Based on information from the tsunami warning center, decision makers will implement evacuation plans in impacted areas.

Action Messages

- Stay informed
- Follow instructions by local authorities

Distant Tsunami Response

- **Response/volunteers helping public evacuate**
- **Communication system overload**

Slide 26. Distant Tsunami Response

Response personnel and volunteers will support the evacuation effort, traffic control, and other requirements for response that have been identified in Tribal and county response plans.

NOTE: Response personnel should leave the tsunami hazard zone at least 20 minutes prior to wave arrival and do not enter it until told to do so.

Expect to have wide spread communication outages. The public should not call 911 or families or friends unless an emergency exists.

Action Messages

- Be familiar with local tsunami response plan
- Do not use your phone except for an emergency

Slide 27. Tsunami Alerts

The slide identifies the 4 types of tsunami alerts that can be received by the Alaska Tsunami Warning Center (TWC) and the appropriate actions that need to be taken.

Tsunami Warning: A tsunami warning is issued when a potential tsunami with significant widespread inundation is imminent or expected. It alerts the public that widespread, dangerous coastal flooding accompanied by powerful currents is possible and may continue for several hours after arrival of the initial wave. Warnings also alert government officials to take action for the entire tsunami hazard zone. Appropriate actions to be taken may include the evacuation of low-lying coastal areas, and the repositioning of ships to deep waters when there is time to safely do so. Warnings may be updated, adjusted geographically, downgraded, or canceled. **To provide the earliest possible alert, initial warnings are normally based only on seismic information.**

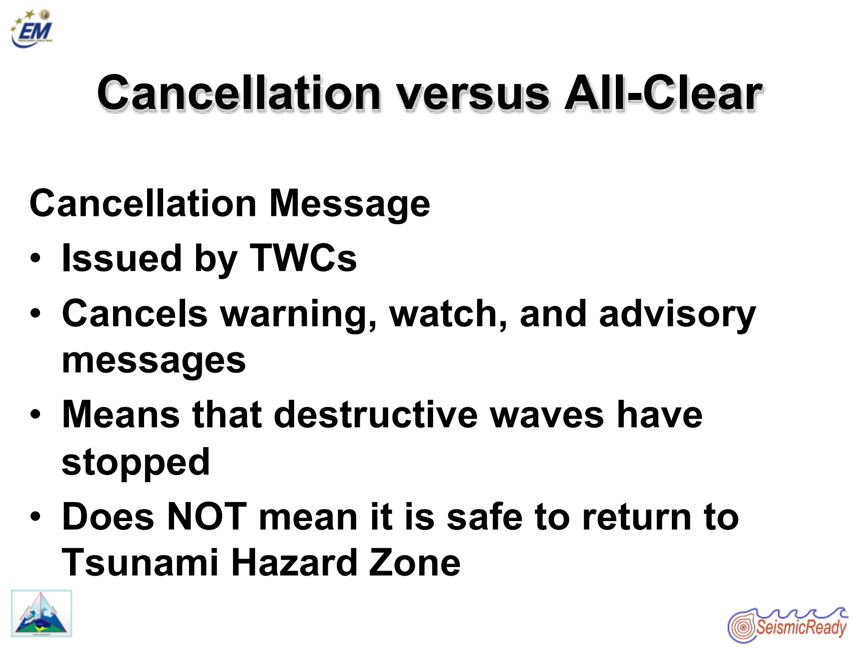
Tsunami Advisory: A tsunami advisory is issued because of a potential tsunami, which may produce strong currents or waves dangerous to those in or near the water. Coastal regions historically prone to damage due to strong currents induced by tsunamis are at the greatest risk. The threat may continue for several hours after the arrival of the initial wave, but significant widespread inundation is not expected for areas under an advisory. Appropriate actions to be taken by local officials include closing beaches, evacuating harbors and marinas, and the repositioning of ships to deep waters when there is time to safely do so. Advisories are normally updated to continue the advisory, expand/contract affected areas, upgrade to a warning, or cancel the advisory.

Slide 27. Tsunami Alerts

(Continued)

<u>Tsunami Watch</u>: A tsunami watch is issued to alert government officials and the public of an event that may later impact the watch area. The watch area may be upgraded to a warning or advisory - or canceled - based on updated information and analysis. Watches are usually issued based on seismic information without confirmation that a destructive tsunami is underway. Normally local governments have 2 or more hours to prepare for a tsunami and one would expect to get evacuation orders if warrant by local authorities.

<u>Tsunami Information Statement</u>: A tsunami information statement is issued to inform government officials and the public that an earthquake has occurred, or that a tsunami warning, watch or advisory has been issued for another region of the ocean. Usually, information statements are issued to indicate (1) there is no threat of a destructive tsunami and to prevent unnecessary evacuations as the earthquake may have been felt in coastal areas or (2) caution about the possibility of destructive local tsunamis. A watch, advisory or warning may be issued for the area, if necessary, after analysis and/or updated information becomes available.



Slide 28. Cancellation versus All Clear

A Cancellation message only cancels previous Tsunami Warnings, Watches and Advisories that have been issued by the Tsunami Warning Center. **It is issued when the tsunami warning center judges that destructive tsunami waves have stopped arriving**. It does not mean it is safe for the public to go back into the Tsunami Hazard Zone. Response can begin in the hazard zone. Local authorities will let the public know when it is safe to return to the Tsunami Hazard Zone.

Action Messages:

- Know Cancellation Message means destructive tsunami waves have stopped
- Stay out of the Tsunami Hazard Zone until you hear an “All-Clear” Message

Cancellation versus All-Clear

All-Clear

- **Issued by local authority**
- **Issued when it is SAFE to re-enter the Tsunami Hazard Zone**

Slide 29. Cancellation versus All Clear

Even though the tsunami threat no longer exists, HAZMAT, fires, down utility lines, unsafe buildings, and other public safety issues may still exist that emergency response personnel are responding too. **The local authority will issue an All Clear once it is safe for the public to re-enter the tsunami hazard zone.**

During the Japanese Tsunami many people returned to the tsunami hazard zone too early in some places because they had not seen the wave arrive at the expected time given in official warnings, or because they expected no more waves to arrive causing many needless deaths. It is critical that citizens follow instructions from local officials and not return to the tsunami hazard zone until given the “All Clear”.

Action Message

Listen for an All-Clear Message before you return to the Tsunami Hazard Zone

Key Official Warning Communication Systems

- **Emergency Alert System: Radio, Television, and NOAA Weather Radio**
- **All Hazard Alert Broadcasting (AHAB) Radio**

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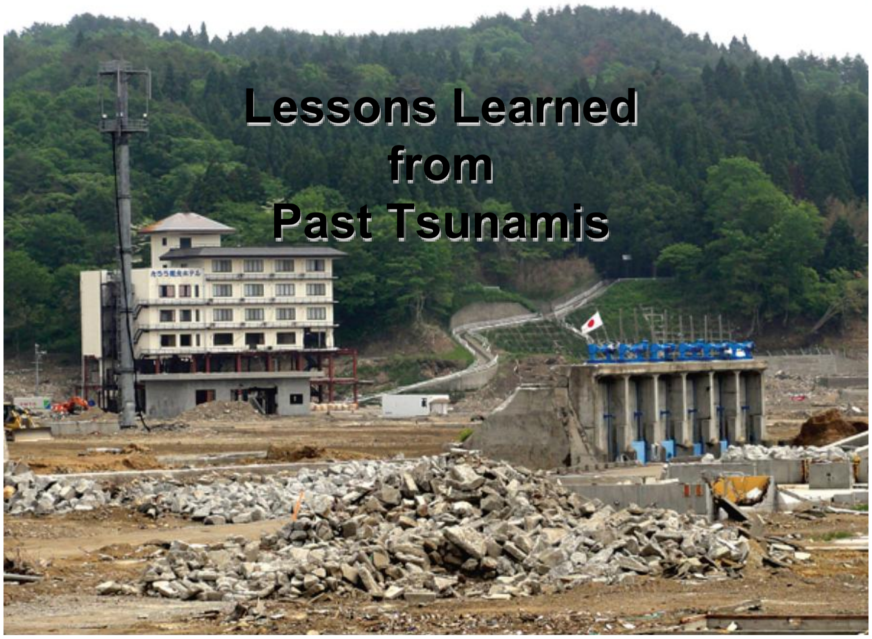
Slide 30. Key Official Warning Communication Systems

The Emergency Alert System (EAS) is a national public warning system that uses TV and radio broadcasters, cable television systems, and other communication providers to transmit emergency information. Washington Emergency Management and local authorities to deliver important emergency information, such as tsunami evacuation and other critical tsunami information to a targeted area along the coast also can use the system.

Communities can use the NOAA Weather Radio as an effective all-hazard alert and notification system. Inexpensive weather radio receivers, some cheaper than a pair of shoes, can warn listeners about a hazard before the mass media and local alert systems can do so, giving people additional time to react before danger hits their area. Review of the June 14, 2005 West Coast Tsunami Warning identified that many residents in tsunami inundation zones who received the tsunami warning over the NOAA Weather Radio or Emergency Alert System broadcast self-evacuated prior to civil authority direction. Because tsunamis can attack shores quickly, every minute counts and communities should have a goal to have NOAA Weather Radios become as common as smoke detectors in homes and businesses as these will help to save lives from natural and technological hazards. To emphasize the importance of owning a NOAA Weather Radio, many jurisdictions have designated a Weather Radio Awareness Month and work with retailers to advertise and sell receivers at a reduced price.

In 2000, Washington State developed a partnership with Federal Signal Corporation to develop a tone/voice system. The All Hazard Alert Broadcasting (AHAB) Radio provides a tone to alert the public, and a voice message instructing them on specific action to take. It uses satellite to monitor system health on a 24x7 basis and to activate the system, while also retaining the option for the state, tribes, and county/local jurisdictions to activate from its emergency operations centers or remotely using handheld equipment.



Slide 31. Lessons Learned from Past Tsunamis

Photo: Taro, Japan, March 2011. Taro was well known as a tsunami-prepared town in Japan. After the 1896 and 1933 tsunamis, as well as the 1960 tsunami, sea walls were built, evacuation maps and signage developed, and exercises conducted. Yet, all this was not enough when waves overtopped the walls, leaving only remnants such as this closed water gate standing. The hotel in the background was flooded to the third floor, but remained standing, as did the tower where the sirens sounded evacuation warnings. Seen at the right back, a gently winding road uphill offered an easy evacuation route to high ground for fleeing citizens. **Credit / Laura Kong, ITIC**

The Washington Tsunami Program continues to strengthen state and local efforts to promote disaster preparation and response capabilities by learning from past tsunami events. It is also critical that our citizens understand lessons learned and take personal responsibility to apply them to their personal preparedness efforts.

The following addresses some of the lessons learned from the 2009 Samoa Earthquake and Tsunami, the 2010 Chile Earthquake and Tsunami and 2011 Japan Earthquake and Tsunami.

2009 Samoa Earthquake and Tsunami

- Factors that reduced vulnerability:
  - ✓ Pre-event Public Education
  - ✓ Time of day
  - ✓ Natural warning signs
  - ✓ Official warning dissemination
- Factors that increased vulnerability:
  - ✓ Clarification and development of evacuation maps and assembly areas

Slide 32. 2009 Samoa Earthquake and Tsunami

The Samoa tsunami occurred early in the morning of September 29, 2009, as families were just waking, and children were preparing to go to school. The tsunami was generated by a magnitude 7.9 earthquake that occurred about 118 miles southeast of Samoa causing 149 deaths in Samoa, 34 in American Samoa, and 9 in Tonga, and damage in Wallis and Futuna. The earthquake caused strong ground shaking to be felt for over 60 seconds with some witnesses reporting it lasted more than two minutes.

The tsunami arrived in Samoa 10-20 minutes after ground shaking stopped. Maximum runup was measured between 45-60 feet in all three countries causing extensive coastal damage to structures and marine and coral reef, and lagoon ecosystems. Pago Pago Harbor, American Samoa, February 2009. The tsunami in Samoa pushed boats into the tops of coconut trees and roofs of office buildings. The Pacific Tsunami Warning Center transmitted its first messages (preliminary earthquake observatory message) 11 minutes after the earthquake and an official warning 16 minutes after the earthquake. Fortunately through intergovernmental tsunami preparedness advocacy developed over the last decade in addition to workshops and trainings by the International Tsunami Information Center and Pacific countries, people had been educated about the tsunami hazard, the importance of pre-event preparedness and, for local tsunamis, the heeding of natural warnings. In other words, no one should wait for an official alert to evacuate. Rather, if you are living near the coast and a big earthquake occurs, unusual or abnormal sea level activities are seen, or you hear a loud roar, you should go to higher ground or inland immediately! This was clearly demonstrated in American Samoa and Samoa, where both countries had saved lives because they were actively engaged in pre-event awareness and education.

2009 Samoa Earthquake and Tsunami

- Factors that reduced vulnerability:
  - ✓ Pre-event Public Education
  - ✓ Time of day
  - ✓ Natural warning signs
  - ✓ Official warning dissemination
- Factors that increased vulnerability:
  - ✓ Clarification and development of evacuation maps and assembly areas

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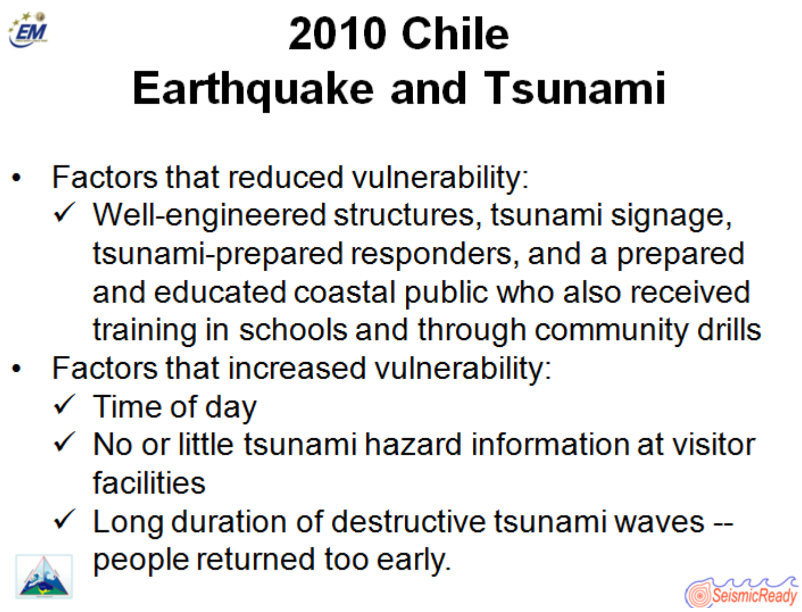
Slide 32. 2009 Samoa Earthquake and Tsunami

(Continued)

Factors which helped to reduce vulnerability for this event were the time of day (many were already awake, but not on the road because the work day had not started), generally limited earthquake damage which reduced injuries and damage to transportation infrastructure, relative closeness and availability of high ground, pre-event plans (such as school evacuation plans in American Samoa) and school and community drills (National Drill in 2007 and 2008 in Samoa). The 2004 Indian Ocean tsunami, and more recently, the March 19, 2009, earthquake off Tonga, also served as reminders of what tsunamis can do, and how warning and response agencies need to coordinate and respond.

Today, the countries are working on recovery issues, and improving their early warning and alert systems, especially in hardening the communications infrastructures critical for providing information on warning and evacuation. Both traditional methods of alerting (bells), and modern media (sirens, mobile phone alerting, radio/TV broadcast), are being strengthened. In addition, at the community and village levels, education and preparedness continues, such as the development and clarification of evacuation maps and routes to safe areas.



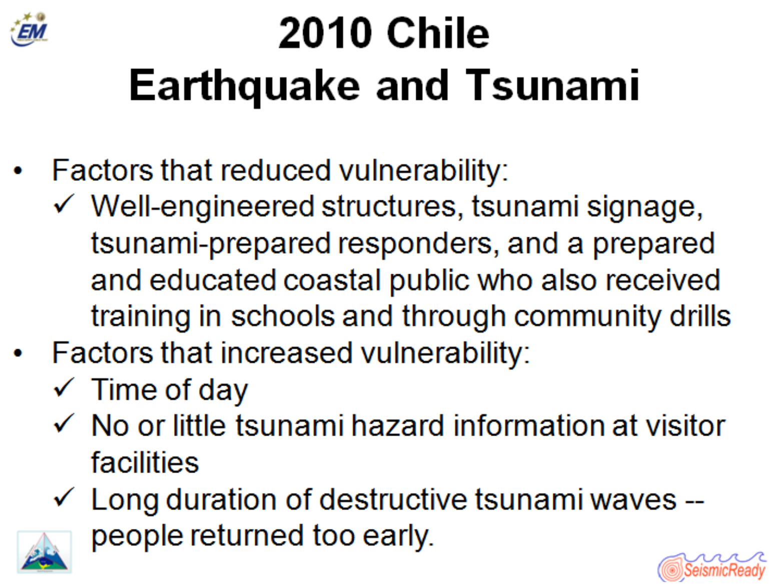
Slide 33. 2010 Chile Earthquake and Tsunami

The 27 February 2010 magnitude 8.8 earthquake generated a tsunami that caused 156 tsunami-related deaths locally. Additionally, in spite of the great size of the earthquake, only a relatively small amount of earthquake damage occurred – this is generally attributed to the strong earthquake building code which structures have been built to over the decades since the 1960 magnitude 9.5 Chilean earthquake.

Similarly for the tsunami, while coastal residential dwellings were destroyed from tsunami waves, very few people lost their lives (compared to the potential vulnerable population, perhaps 100,000+ people) – this is largely attributed to pre-event preparedness, awareness, and education. Elders who lived through the 1960 tsunami passed on their experience and wise advice to their children and grandchildren, and the 2004 Indian Ocean tsunami and more recent earthquakes reminded everyone of the need to be aware and prepare. The Chilean Navy's Hydrographic Service, Chile disaster management agency, and universities and community organizations led these efforts; inundation maps, hazard and evacuation signage, and awareness and education materials were distributed along the coasts. Without these efforts for the decades before, it is sure that many more would have perished.

Factors that helped reduce vulnerability for this event were generally limited earthquake damage due to well-engineered structures, tsunami signage, tsunami-prepared police and fire responders who assisted in warning and evacuation, and a prepared and educated coastal public who also received training in schools and through in-community practice drills.

Factors that unfortunately increased the vulnerability were the time of day (many were sleeping so that the earthquake was their early warning), no or little tsunami hazard information at visitor facilities (such as campgrounds) to help uninformed/unaware tourists and workers, and the long duration of destructive tsunami waves (several to 4 hrs. so people returned too early).

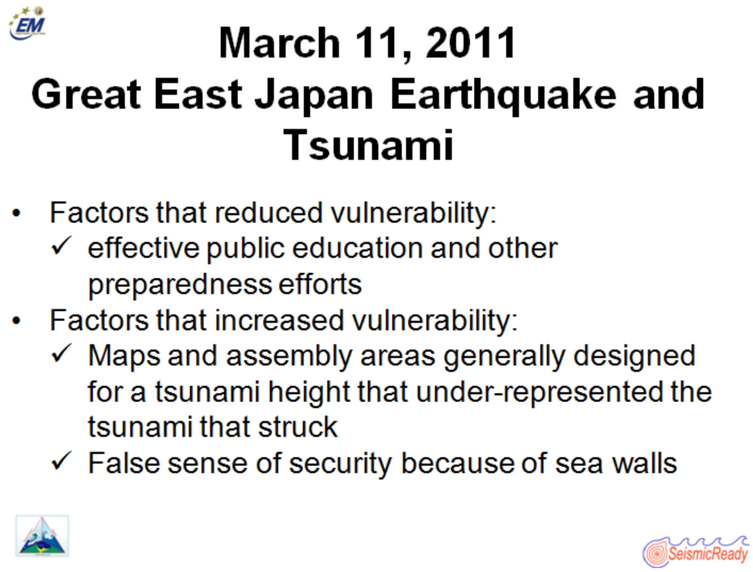


Slide 33. 2010 Chile Earthquake and Tsunami

(Continued)

In the town of Constitucion, where 45 died, inopportune timing was the principal cause of death, as many were camping on an island at the river mouth with no evacuation method, and the tsunami hit the night after a summer-ending fireworks celebration.

Today, like in the South Pacific, Chile is working to strengthen their early warning systems, especially in hardening the communications infrastructures critical for providing information on warning and evacuation, and in improving the earthquake and tsunami detection networks to more quickly assess tsunami threat to their coasts. Many are aware that the next tsunami will probably be to the north where there is already a long history of destructive tsunamis. Awareness and outreach campaigns in this region aim to further strengthen community preparedness. Again, the emphasis for local tsunamis is to ensure that everyone knows a tsunami's natural warning signs and then knows to immediately take action since the tsunami may attack coasts within 10-30 minutes after the earthquake.



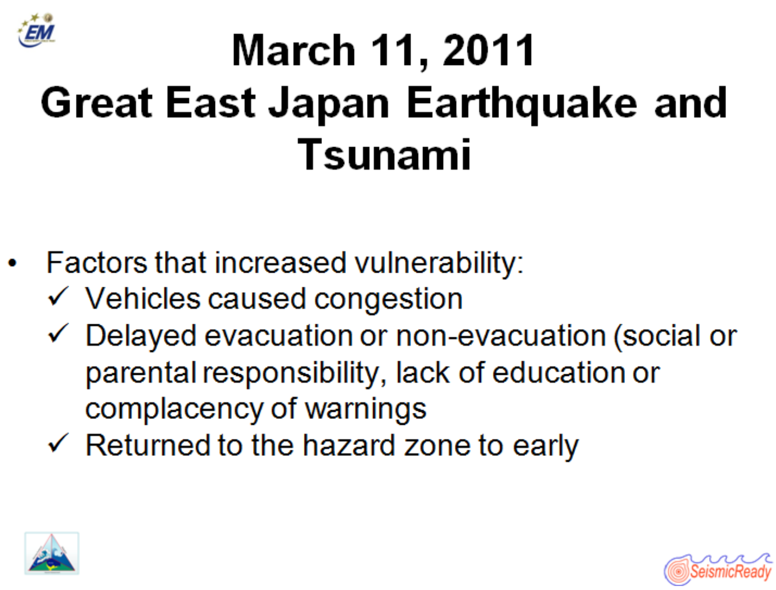
Slide 34. March 2011 Great East Japan Earthquake and Tsunami

The March 11, 2011, M9.0 earthquake generated a devastating local tsunami that struck the Pacific coast of Honshu within about 20 minutes. On January 12, 2012, the Japan National Police Agency reported 13,895 persons killed and 13,864 persons missing from the earthquake and tsunami. 141,343 residents are still staying at evacuation shelters. The 2011 Japan Earthquake Tsunami Joint Survey Group (http://www.coastal.jp/tsunami2011/) reports tsunami run up heights up to 100 feet with a maximum of nearly 130 feet. The 11 March 2011 Japanese tsunami was the first to cause deaths since the 1993 Sea of Japan magnitude 7.7 earthquake caused 23 deaths and generated a tsunami that caused an additional 208, and the most fatal tsunami globally since the 2004 Indian Ocean tsunami generated off Sumatra, Indonesia that killed nearly 230,000 across the Indian Ocean.

The Japanese Meteorological Agency's national tsunami warning center issued a tsunami warning 3 minutes after the earthquake triggering the alerting process that immediately broadcasted by mass media and locally activated sirens and other mitigation countermeasures such as water gate closures. Live video of the advancing tsunami waves and their impact on structures at the coast was aired live by Japan NHK television and seen at the same time globally.

Factors that helped reduce vulnerability for this event was mostly due to effective education and evacuation programs and procedures. Schools education, hazard maps and exercises are common forms of education. Communities are involved in planning of evacuation maps, routes and buildings with many places conducting regular community-level exercises.

Despite Japan's sustained and globally recognized excellence in tsunami preparedness, many casualties resulted from the swiftness and destructive power of the tsunami. Waves overtopped



Slide 35. March 2011 Great East Japan Earthquake and Tsunami

(Continued)

tsunami walls and destroyed many structures, especially wooden homes. Like the previous tsunamis, drowning was the main cause of death, with casualties greatest in the elderly.

Factors that also increased the vulnerability included:

- Maps and safe locations that were generally designed for a tsunami height that under-represented the worst case scenario,
- The natural warning of long ground shaking was enough by itself to have triggered evacuation. However, sea walls reduced effective observation of the natural warning of unusual ocean behavior in many places, and fostered a false sense of security in some locations.
- Widespread use of motor vehicles caused traffic congestion in some areas (failure of traffic signals because of power outage, poor road conditions because of the earthquake etc.) when walking, running or cycling would have been much more effective and saved lives.
- Many people returned to the tsunami hazard zone too early in some places because they had not seen the wave arrive at the expected time given in official warnings, or because they expected no more waves to arrive. Never return to the tsunami hazard zone until directed by local authority.

The tsunami also propagated across the entire Pacific Ocean, with runups up 15 feet and $30 million in damage to harbors and homes in Hawaii 7 hours later, up to 9 feet and $50 million in damage in California 12 hours later, and up to 9 feet heights and more than $4 million in damage 22 hours later in Chile. Outside of Japan, 1person died in California, USA, and 1 person died in Papua, Indonesia.

Fleeing the tsunami, Hilo, 1946

"Five minutes before the party is not the time to learn to dance."

Snoopy, circa 1982

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Slide 36.

Photo: Earthquake occurred on Apr 1, 1946 in the Aleutian Island of Alaska. Tsunami arrived 4.9 hours after the tsunami was generated. It caused $26 million (1946 dollars) and 96 people lost their lives. Through public education forums like we are doing today, the lost of life can be reduced drastically. **Source**: Bishop Museum Archives.

Preparedness is ongoing and is never ending. We must learn from past tsunamis and not allow the same tragedy to happen to us. We will deal with either a local tsunami (example: 1700 Cascadia Subduction Zone Earthquake/Tsunami) where you have less than 30 minutes to react or a distant tsunami (example: 1964 Alaska Earthquake/Tsunami) where we have several hours to react. The response for both types of tsunamis is different – your lives and those of your love ones depend on the correct response actions.

Public Education Saves Lives

Thank You for helping making a difference!

SeismicReady

Slide 37. Public Education Saves Live

Since 1900, more than 100 tsunamis have impacted the Pacific U.S. states and territories. These U.S. tsunami events have killed 392 people and caused over $1.6 billion in damages. They include the fifth and sixth largest earthquakes ever recorded. With your help, we can reduce the loss of life from the next tsunami that strikes our shores.

Washington's coastal residents are particularly at risk from either an eastern Aleutian Island Subduction Zone tsunami or a Cascadia Subduction Zone earthquake and tsunami. A tsunami generated off our coast from a Cascadia Subduction Zone earthquake will arrive on Washington shores in 30 minutes or less with maximum force. People will be preoccupied with major damage from the earthquake. The tsunami waves will reach shore before they are registered clearly at the nearest detection buoy, and they will also reach people on the beach or low lying areas sooner than a tsunami warning center's message can warn them.

More lives will be saved through education about earthquakes and tsunamis than through man-made warning systems. As illustrated in the 2009 American Samoa Tsunami, the mayor of Amenave in American Samoa had attended tsunami awareness training and was taught natural warning signs. When he felt the ground shaking from the earthquake, he knew that his people must head to high ground immediately before the tsunami struck. He grabbed his bullhorn and ran through the village notifying people to evacuate immediately. Because of his actions, most villagers' lives were saved, even though their community was completely destroyed.

With your help, we can reduce the loss of life from our next local tsunami.

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